SIGNIFICANT CENTERS OF TECTONIC ACTIVITY AS IDENTIFIED BY WRINKLE RIDGES FOR THE WESTERN HEMISPHERE OF MARS.

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Introduction: The western hemisphere region of Mars has been the site of numerous scientific investigations regarding its tectonic evolution. For this region of Mars, the dominant tectonic region is the Tharsis province. Tharsis is characterized by an enormous system of radiating grabens and a circumferential system of wrinkle ridges. Past investigations of grabens associated with Tharsis have identified specific centers of tectonic activity [1, 2, 3, 4, 5, 6]. A recent structural analysis of the western hemisphere region of Mars [7, 8], which includes the Tharsis region, utilized 25,000 structures to determine the history of local and regional centers of tectonic activity based primarily on the spatial and temporal relationships of extensional features. This investigation revealed that Tharsis is more structurally complex (heterogeneous) than has been previously identified: it consists of numerous regional and local centers of tectonic activity (some are more dominant and/or more long lived than others). Here we use the same approach as Anderson et al., 1998 [8] to determine whether the centers of tectonic activity that formed the extensional features also contributed to wrinkle ridge (compressional) formation.

Wrinkle Ridges: Faults and wrinkle ridges are structural features that have been identified on the surface of Mars. Wrinkle ridges are complex, asymmetrical, sinuous to linear topographic highs. Although wrinkle ridges are recognized as structural features, their origin is still controversial. Like similar structures on the lunar maria and on the planet Mercury, these features have been interpreted to be folds formed by compression [5, 9, 10, 11, 12, 13, 14] or volcanic extrusions and dikes of high viscosity magmas intruded along extensional faults and grabens [15, 16, 17, 18, 19].

Methodology: A variety of studies have attempted to use the location and orientation of tectonic features on Mars to constrain the geometry of the causative stress field for this region. Because the orientaion of these structures is a direct result of the geometry of the stress field over the region, the orientation of grabens and wrinkle ridges can be used to test the true radial nature of the causative stress fields [5]. For this investigation, 4,554 compressional features of the western equatorial region (90°N to 90°S latitude and 0°to 180°W longitude) were mapped, digitized, and characterized on Viking images and 1:2,000,000-scale photomosaic bases and compiled into a workable spreadsheet format. Each digitized structure consists of an x-y reference for its beginning and ending points, which were converted into martian coordinates for correlation and reverification with the 1:2,000,000-scale base maps. For simplification, sinuous features were subdivided into multiple linear segments along natural breaks in trend and structure was carefully checked and verified for accuracy. For this analysis, normals to the wrinkle ridges are assumed to represent the S_1 - S_3 plane. In this study, we modified a technique previously used for identification of radial centers of uplift on Earth [20] and Mars [14]. Each feature was projected as a great circle, and spherical geometry was used to identify the number of grid points normal to the features' midpoint. Areas of high concentrations represent significant centers of tectonic activity normal to the direction of the compressional ridges. These centers were then compared to previously identified centers of tectonic activity identified by Anderson et al., 1998 based on 20,000 mapped and relative aged dated extensional features.

Preliminary Results and Conclusions: Figure 1 is a composite map of all wrinkle ridges for the western hemisphere region of Mars. Lunae Planum emerges as the region of densest wrinkle ridge concentration. This is in agreement with previous studies concerning wrinkle ridge formation for the western hemisphere region of Mars. Figure 2 is a contour plot derived from the modified Fracture Intersection method. From this plot, at least two centers of tectonic activity are visible: a long, linear region stretching from 15°S, 95°W to 4°N, 125°W; and a smaller linear region centered around 20°N and ranging from 40° to 70° W. The location of the centers are in general agreement with those obtained by using a beta analysis technique and a different data set[14].

Of the two centers of tectonic activity identified from this study, the one, which is located in Syria Planum region (Figure 2, labelled A), is in agreement with the primary Hesperian center of tectonic activity , Syria Planum normal faults (Stage 3) identified by Anderson et al., 1998 [8]. On the other hand, the Lunae Planum center (labelled B on Figure 2) which has been previously identified by Watters, 1993 [14], was not identified in the study by Anderson et al., 1998 [8] using extensional features. Further examination of the extensional features from their study is required to see if this center may represent a local center of tectonic activity.

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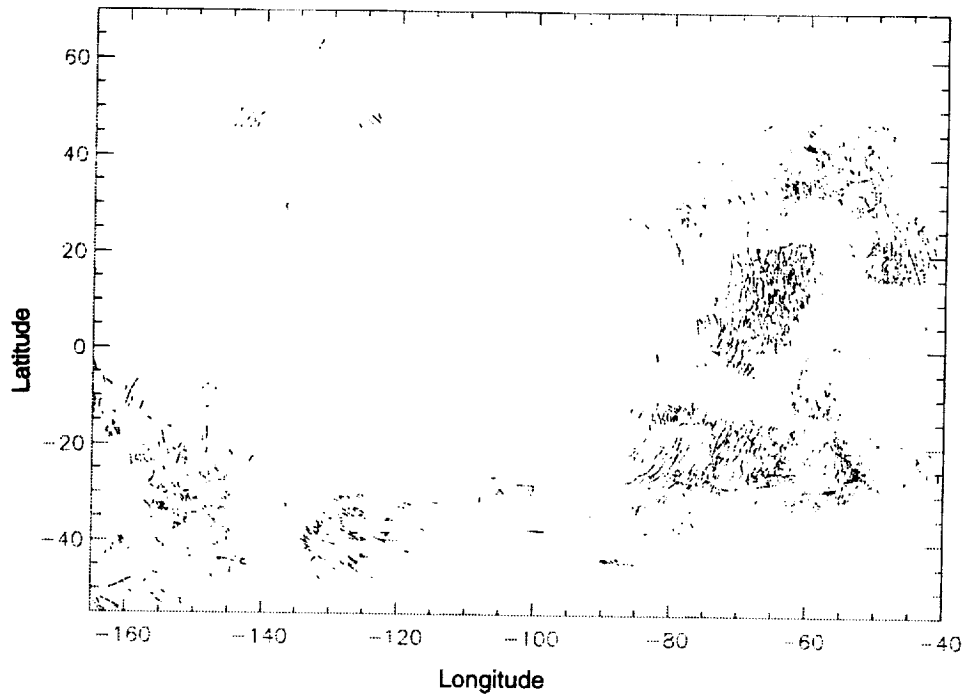
Figure 1 Composite map of compressional features for the western hemisphere of Mars.
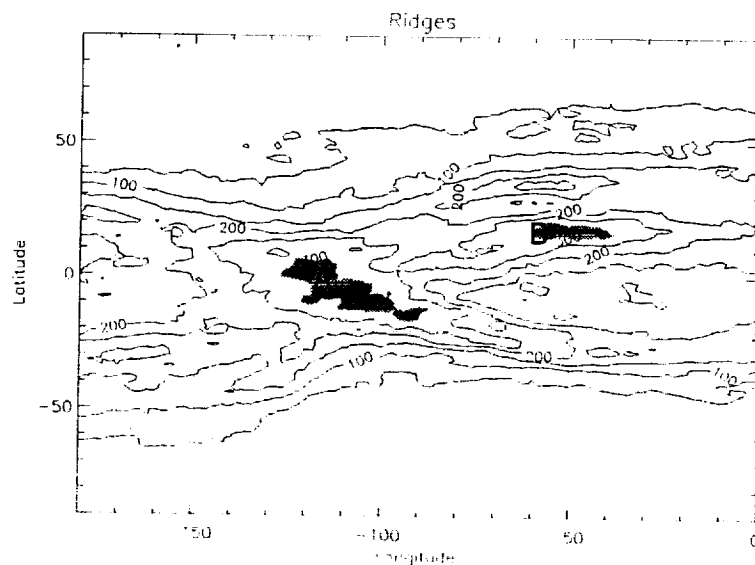
Figure 2 Contour plot of normals to the compressional features. Areas of high concentrations are in gray and represent significant centers of tectonic activity: A = Syria Planum, B = Lunae Planum.